

CLAIMS

1. A method for forming silicon dioxide (SiO₂) on a silicon carbide (SiC) substrate, the method comprising:
 - providing a SiC substrate;
 - 5 supplying an atmosphere including oxygen;
 - performing a high-density (HD) plasma-based process; and,
 - forming a SiO₂ layer overlying the SiC substrate.
2. The method of claim 1 wherein performing an HD
10 plasma-based process includes connecting a top electrode to an inductively coupled HD plasma source.
3. The method of claim 2 wherein performing an HD plasma-based process includes:
 - 15 performing an HD plasma oxidation process:
 - in response to the HD oxidation process,
 - creating a reactive oxygen species;
 - breaking the Si-C bonds in the SiC substrate, to
 - form free Si and C atoms in the SiC substrate; and,
 - 20 wherein forming a SiO₂ layer overlying the SiC substrate
 - includes bonding the free Si atoms in the SiC substrate to the HD plasma-generated reactive oxygen species, and growing the SiO₂ layer.
4. The method of claim 3 wherein providing a SiC
25 substrate includes maintaining the SiC substrate at a temperature of 360 degrees C, or less.

5. The method of claim 3 wherein supplying an atmosphere including oxygen includes supplying O₂ with an inert gas, where the ratio of inert gas to O₂ is in the range between 10:1 and 200:1.

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6. The method of claim 5 wherein supplying the O₂ with an inert gas includes using an inert gas selected from the group including He, Kr, and Ar.

10 7. The method of claim 3 wherein performing an HD plasma-based process further includes bonding the free C atoms in the SiC substrate with the reactive oxygen species, forming carbon monoxide (CO); and

the method further comprising:

15 removing the CO from the process.

8. The method of claim 3 wherein supplying an atmosphere including oxygen includes supplying a pressure of up to 500 milliTorr (mTorr), with a mixture of inert gas and oxygen in a ratio of approximately 10:1 to 200:1, and a total gas flow of approximately 50 to 200 standard cubic centimeters per minute (sccm); and,

wherein performing a HD plasma-based oxidation process includes:

25 locating the SiC substrate between a bottom electrode and the top electrode;

supplying a power density of up to 10 watts per square centimeter (W/cm^2), at a frequency in the range of 13.56 to 300 megahertz (MHz), to the top electrode; and,

supplying a power density of up to $3 \text{ W}/\text{cm}^2$, at a
5 frequency in the range of 50 kilohertz (KHz) to 13.56 MHz, to the bottom electrode.

9. The method of claim 3 wherein supplying an atmosphere including oxygen includes supplying a He/O₂ atmosphere;
10 and,

wherein forming a SiO₂ layer overlying the SiC substrate includes forming a SiO₂ layer at deposition rate of about 100 Å, in 10 minutes.

15 10. The method of claim 2 wherein supplying an atmosphere including oxygen includes supplying SiH₄, N₂O, and N₂; wherein performing an HD plasma-based process includes:

performing an HD plasma enhanced chemical vapor deposition (PECVD) process; and,

20 in response to the HD PECVD process, causing a reaction between the gases in the atmosphere; and,

wherein forming a SiO₂ layer overlying the SiC substrate includes depositing a SiO₂ layer over the SiC.

11. The method of claim 10 providing a SiC substrate includes maintaining the SiC substrate at a temperature of 400 degrees C, or less.

5 12. The method of claim 10 wherein supplying SiH₄, N₂O, and N₂ includes supplying SiH₄, N₂O, and N₂ in a ratio of 10-25:100:50.

13. The method of claim 10 wherein supplying an atmosphere including oxygen includes maintaining an atmosphere
10 pressure in the range of 10 to 500 mTorr.

14. The method of claim 10 wherein supplying an atmosphere including oxygen includes supplying a pressure of up to 500 mTorr, with a mixture of inert gas and oxygen in a ratio of approximately
15 10:1 to 200:1, and a total gas flow of approximately 50 to 200 sccm; and, wherein performing a HD PECVD process includes:

locating the SiC substrate between a bottom electrode and the top electrode;

supplying a power density of up to 10 W/cm², at
20 a frequency in the range of 13.56 to 300 MHz, to the top electrode; and,

supplying a power density of up to 3 W/cm², at a frequency in the range of 50 KHz to 13.56 MHz, to the bottom electrode.

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15. The method of claim 10 wherein forming a SiO₂ layer overlying the SiC substrate includes forming a SiO₂ layer having a bias temperature stress (BTS) of less than 1 volt, at 150 degrees C, with a bias voltage of +/- 2 megavolts per centimeter (MV/cm).

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16. The method of claim 10 wherein forming a SiO₂ layer overlying the SiC substrate includes forming a SiO₂ layer having a breakdown strength of greater than 10 MV/cm.

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17. The method of claim 10 wherein forming a SiO₂ layer overlying the SiC substrate includes forming a SiO₂ layer having a leakage current density of less than 1×10^{-7} amps per square centimeter (A/cm²), at an applied field of 8 MV/cm.

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18. The method of claim 10 providing a SiC substrate includes maintaining the SiC substrate at a temperature of 150 degrees C, or less.

19. The method of claim 2 further comprising:
20 prior to the HD plasma-based process, depositing a Si layer overlying the SiC substrate;

wherein performing an HD plasma-based process includes:

performing an HD oxidation process;

in response to the HD oxidation process,

25 creating a reactive oxygen species;

23. The method of claim 22 wherein supplying a pressure of up to 500 mTorr, with a mixture of inert gas and oxygen in a ratio of approximately 10:1 to 200:1, includes mixing oxygen with inert gas
5 selected from the group including helium, argon, and krypton.

24. The method of claim 2 further comprising:
depositing a Si layer;
wherein performing an HD plasma-based process includes:
10 initially performing an HD oxidation process;
in response to the HD oxidation process,
creating a reactive oxygen species;
wherein performing an HD plasma-based process includes:
subsequently performing a HD PECVD process;
15 in response to the HD PECVD process, causing
a reaction between gases in the atmosphere;
wherein supplying an atmosphere including oxygen includes,
with respect to the PECVD process, supplying SiH₄, N₂O, and N₂;
wherein forming a SiO₂ layer overlying the SiC substrate
20 includes a combination of growing and depositing a SiO₂ layer over the Si
layer.

25. The method of claim 24 wherein depositing a Si layer overlying the SiC substrate includes depositing a Si layer selected from
25 the group including amorphous Si, polycrystalline Si, and single-crystal Si.

30. The method of claim 29 wherein supplying an atmosphere including oxygen includes supplying a pressure of up to 500 mTorr, with a mixture of inert gas and oxygen in a ratio of approximately 10:1 to 200:1, and a total gas flow of approximately 50 to 200 sccm; and,

5 wherein performing a HD PECVD process includes:

locating the SiC substrate between a bottom electrode and the top electrode;

supplying a power density of up to 10 W/cm^2 , at a frequency in the range of 13.56 to 300 MHz, to the top electrode;

10 and,

supplying a power density of up to 3 W/cm^2 , at a frequency in the range of 50 KHz to 13.56 MHz, to the bottom electrode.

15 31. The method of claim 2 wherein performing an HD plasma-based process includes:

performing an HD oxidation process;

in response to the HD oxidation process,

creating a reactive oxygen species;

20 wherein forming a SiO₂ layer overlying the SiC substrate includes bonding the free Si atoms in the SiC substrate to the HD plasma-generated reactive oxygen species, and growing the SiO₂ layer;

the method further comprising:

25 etching the SiO₂ layer, exposing a region of the SiC substrate; and,

depositing a metal in the exposed region of SiC substrate to form a metal-semiconductor contact.

32. A method for growing silicon dioxide (SiO₂) on a
5 silicon carbide (SiC) substrate, the method comprising:
providing a SiC substrate at a temperature of 360 degrees C,
or less;
supplying an atmosphere including oxygen;
performing a high-density (HD) plasma oxidation process;
10 in response to the HD oxidation process, creating a reactive
oxygen species;
breaking the Si-C bonds in the SiC substrate, to form free Si
and C atoms in the SiC substrate; and,
bonding the free Si atoms in the SiC substrate to the HD
15 plasma-generated reactive oxygen species, and growing the SiO₂ layer.

33. A method for depositing silicon dioxide (SiO₂) on a
silicon carbide (SiC) substrate, the method comprising:
providing a SiC substrate at a temperature of 400 degrees C,
20 or less;
supplying an atmosphere including SiH₄, N₂O, and N₂;
performing a high-density (HD) plasma enhanced chemical
vapor deposition (PECVD) process;
in response to the HD PECVD process, causing a reaction
25 between the gases in the atmosphere; and,
depositing a SiO₂ layer over the SiC.

34. A method for growing silicon dioxide (SiO₂) on a Si/silicon carbide (SiC) structure, the method comprising:
providing a SiC substrate at a temperature of 400 degrees C,
5 or less;
depositing a layer of Si overlying the SiC;
supplying an atmosphere including oxygen;
performing a high-density (HD) oxidation process;
in response to the HD oxidation process, creating a reactive
10 oxygen species; and,
bonding Si atoms in the Si layer to the reactive oxygen species, growing a SiO₂ layer overlying the Si layer.

35. A method for forming silicon dioxide (SiO₂) on a Si/silicon carbide (SiC) structure, the method comprising:
15 providing a SiC substrate at a temperature of 400 degrees, or less;
depositing a Si layer overlying the SiC;
supplying an atmosphere including oxygen;
20 initially performing a high-density (HD) oxidation process;
in response to the HD oxidation process, creating a reactive oxygen species;
subsequently performing a HD PECVD process;
in response to the HD PECVD process, causing a reaction
25 between SiH₄, N₂O, and N₂ gases in the atmosphere;

forming a SiO₂ layer overlying the Si layer by a combination of growing and depositing SiO₂ layer.

36. A method for forming a Schottky contact on a silicon
5 carbide (SiC) substrate, the method comprising:
- providing a SiC substrate;
 - supplying an atmosphere including oxygen;
 - performing a high-density (HD) oxidation process;
 - in response to the HD oxidation process, creating a reactive
10 oxygen species;
 - bonding the free Si atoms in the SiC substrate to the HD
plasma-generated reactive oxygen species, and growing an SiO₂ layer;
 - etching the SiO₂ layer, exposing a region of the SiC
substrate; and,
 - 15 depositing a metal in the exposed region of SiC substrate to
form a metal-semiconductor contact.